

to Miss Elsie M. Blackwell & Co  
with kindest regards

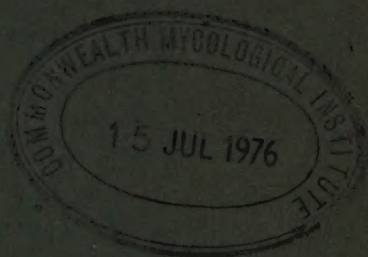
# ECONOMIC MYCOLOGY:

## The Beneficial and Injurious Influences of Fungi.

(Being the Presidential Address delivered to the Yorkshire  
Naturalists' Union, at Selby, Dec. 2nd, 1916).

BY

W. N. CHEESMAN, J.P., F.L.S.



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## ECONOMIC MYCOLOGY: THE BENEFICIAL AND INJURIOUS INFLUENCES OF FUNGI.\*

W. N. CHEESMAN, J.P., F.L.S.

WE meet for the third time under the cloud of a great European War, the most terrible war the world has ever seen. Let us hope that when the successful end is accomplished, and the silver lining comes into sight, means will be adopted to prevent the repetition of such a world's calamity.

May nations in the future strive only to excel in the peaceful arts and sciences, and in the production of things which may tend to the happiness and betterment of mankind.

Already the attitude of the public mind towards science in relation to commerce and industry is hopeful and encouraging.

Although Mr. Crossland, in his Presidential Address in 1908, acknowledged the part taken by the early workers in Mycology, I feel that no reference should be made to Yorkshire Mycology without expressing deep appreciation of the great help rendered to the workers by Mr. George Massee, for many years the head of the Cryptogamic Department in the Royal Herbarium at Kew, and who for forty years has been the mainstay of the section in our county.†

Others who have rendered yeoman service in their time, and who have passed away may be mentioned: The Revd. Canon Fowler, Dr. Franklin Parsons, R. H. Philip, H. T. Soppitt and William West.

All honour and appreciation is due to our esteemed veteran and past President of the Union, the late Charles Crossland, who for many years laboured most assiduously and successfully in the Mycological work of the county. We have still with us energetic workers in the persons of Dr. Harold Wager (Chairman of the Mycological section), Alfred Clarke, Thomas Gibbs, Sir Henry Hawley and others, all of whom are doing useful work in their different departments.

To define a group of plants of such varying characters as the Fungi is not an easy matter. The number of species is computed to be over seventy thousand, the forms, sizes and colours of which range over an enormous extent. Perhaps the most concise definition is 'Cryptogams minus chlorophyll,' meaning that they belong to one of the lowest groups of vegetation, having the reproductive organs hidden or concealed, and that they are devoid of chlorophyll, the green colouring

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\* Being the Presidential Address to the Yorkshire Naturalists' Union, delivered at Selby on December 2nd, 1916.

† Since the above was written we have had to deplore the loss of both Geo. Massee and Chas. Crossland.

matter of plants; thus they are unable to elaborate their food from inorganic matter and can only subsist as parasites or saprophytes on organic substances.

The economic value of Fungi is of greater importance to mankind than that of any of the other classes of Cryptogamia, although they are generally supposed to militate for injury rather than for benefit. Certainly in many ways Fungi are injurious to man, but the good services they render balance their occasional devastations. Truly Fungi may be rightly called 'Nature's Refuse Destructors,' for they have the power of reducing to the natural elements the accumulations of non-living vegetable and animal substances, which, but for these powers of operation would soon render many parts of the world untenable.

The spores of Fungi are so small and light that they float in the air in considerable quantities, and the work of destruction at once commences when the spores alight on material forming a suitable nidus, given the requisite amount of moisture and warmth.

Their power of multiplication is enormous (much greater than that of any other class of organisms), and when their allotted task is accomplished they swiftly disappear after running their life's course, diffusing their spores in the atmosphere ready again for similar destructive work, like the comparison of motor and horse traction, where the former only requires feeding when active service is required, and the latter needing food whether at work or at rest, so the Fungi spring suddenly into existence when their services are required, complete their work of destruction, and then returning to their latent unnoticed state, ready, however, at a moments warning, again to be developed.

Other benefits which mankind derive from Fungi may be mentioned: (i.) Their value as a food supply; (ii.) Their uses in medicine; and (iii.) In the arts of brewing, cheesemaking, tanning, &c.

That the ancients were acquainted with the food value of Fungi is proved by allusions to the same in many of the classical writings. The botanical remains of Theophrastus (d. B.C. 287), contain several references to Boleti (under which name all large fungi went) describing their forms, habitats and qualities. Nicander, the poet-physician, who flourished a century later, in his work on 'Poisons and their Antidotes,' enumerates several species of fungi which were considered to be poisonous, the growth of which he attributes to 'fermentation,' and recommending amongst other remedies a mustard emetic for those who had inadvertently eaten poisonous Fungi.

The 'Materia Medica' of Dioscorides (circa A.D. 50)

describes between 500 and 600 plants, chiefly medicinal; in it is the first mention of the word *Agaricum*, which word has been adopted by modern mycologists for the large group of gilled Fungi of which we have in Britain over a thousand species. Dioscorides says: 'Fungi (*μύκρηες*) have a twofold difference, for they are either good for food or poisonous,' and indicates one species as being useful for 'imparting a sweet taste to sauces,' also recommending that the edible fungi be cooked in oil and with much honey.

Pliny (b. A.D. 23) tells us in his 'Natural History' much about the preparation of the dishes of *Boleti* which was one of the luxuries of the wealthy Romans. The Fungi were to be prepared by the epicures themselves with amber knives and silver service, and were never to be trusted in the hands of servants, for he says it would be safer to send silver or gold by a messenger than to trust him with *Boleti*. 'Argentum atque aurum facile est lænamque togamque mittere: *Boletos* mittere difficile est.'—Ep. XIII. 48.

The correct description given by Pliny of several of the edible Fungi enables us to recognise some well-known species.

The death of Claudius Cæsar (A.D. 54) by poisoning was attributed to a dish of his favourite *Boleti* prepared by the Empress Agrippina, but whether the poison was originally in the Fungi or introduced by Agrippina (as Pliny asserts), we are not in a position now to determine, but the case will suffice to show that the eating of Fungi by the wealthy Romans was prevalent, and by them esteemed a luxury, notwithstanding the constant warnings against the possibility of poisoning.

These warnings, which were so frequently given by the ancient writers, might serve as an argument against the use of Fungi as an article of diet, but we must bear in mind the crude state of botanical knowledge, especially in mycology, which the ancients had, and their ignorance of structure, affinities, classification and chemical properties which the mycologists of the twentieth century possess. The number of species of Fungi named and recognised by the ancient botanists would probably not exceed a score and these were the large species considered to be suitable for food. The absence of proper descriptive characters would lead to mistakes being made, often with serious consequences.

It may be of interest to state what a very distinguished Selby botanist wrote three hundred years ago. This Selby born man, Thomas Johnson by name, wrote an amended edition of Gerard's *Herbal* in 1633, and in the chapter on Fungi, he says:—

'Some mushrumes grow forth of the earth, other upon the bodies of old trees, which differ altogether in kindes. Many wantons that dwell neere the sea, and have fish at will, are

very desirous for change of diet to feed upon the birds of the mountaines; and such as dwell upon the hills or champion grounds do long after sea fish; many that have plenty of both do hunger after the earthy excrescences called Mushromes; whereof some are very venomous and full of poyson, others not so noisome; and neither of them very wholesome meate, wherefore for the avoiding of the venomous quality of the one, and that the other which is less venomous may be discerned from it, I have thought good to set forth their figures with their names and places of growth.\*

'Divers esteeme those for the best which ggrow in medowes and upon mountaines and hilly places, as Horace saith, lib. ser. 2. Satyr 4:

..... pratensibus optima fungis.  
Natura est, alijs, malè creditur.

The meadow Mushroms are in kind the best.  
It is ill trusting any of the rest.

Galen affirms that in their Temperature and Virtues, they are very cold and moist, and therefore to approach unto a venomous and murthering facultie, and ingender a clammy, pituitous and cold nutriment if they be eaten. To conclude, few of them are good to be eaten, and most of them do suffocate and strangle the eater. Therefore I give my advice unto those that love such strange and new fangled meates, to beware of licking honey among thornes, least the sweetnesse of the one do not countervaille the sharpnesse and pricking of the other.'

Parkinson divides the group into *Fungi esculenti* (32 sp.) and *Fungi perniciosi* (32 sp.), finishing with 'Thus have I shewed you all the kindes and sorts of Mushromes, both wholesome and dangerous.'

This was written in 1640, so we may assume that at least sixty-four species of Fungi were then known and recognised.

Carolus Clusius, who was born at Antwerp in 1526, published his book entitled '*Rariorum Plantarum Historia*,' in which he gives an appendix on 'Mushromes,' observing that they grew more abundantly in moist weather after thunder. It is left for the present day mycologist to explain the cause of this. Massee thinks that the nitric acid generated in the atmosphere by the thunder is brought down by the rain thus accelerating the growth of fungi. The same cause is given for the curdling of milk and souring of beer in thundery weather.

That thunder exercised some peculiar power in producing

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\* Gerard's Herbal, 2nd edition, by Thos. Johnson, 1633. With all respect to my fellow townsmen, I venture to think that had he lived in this twentieth century, he would probably be standing before you as the President of the Yorkshire Naturalists' Union, and expressing similar thoughts to those I have the honour of lay before you.

fungi was an opinion current among the ancients, and Plutarch has given us a long and curious dissertation in his 'Symposiacs' (Book IV.) on the question 'Why fungi are thought to be produced by thunder.' At a certain supper in Elis, where large truffles were found, some of extraordinary size were set on the table. Many of the guests seemed to wonder, whereupon some individual jokingly referred to the thunderstorms which had lately happened as being the cause of their appearance, meaning to deride the popular opinion as absurd; whereupon Agemachus, the worthy host prayed the company not to conclude a thing was incredible because it was strange and wonderful. The influence of thunder rains on truffles is referred to by Juvenal, who also speaks of the great estimation in which they were held—

'Post hunc tradentur tubera, si ver  
Tunc erit et facient optata tonitrua cœnas  
Majores, Tibi habe frumentum, Alledius inquit,  
O Libye; disjunge boves, dum tubera mittas!'

Sat. V., 116-119.

The economic value of Fungi as an article of food is undoubted. During these strenuous times when everyone is advising war economy, it behoves us to look round and see how we can further utilise the 'fruits of the earth' for increasing our food supplies; and it is somewhat sad to see the vast quantities of edible and nutritious fungi which every season are allowed to waste for want of knowledge as to their food value.

They surpass all other vegetable products in the richness of their proteids, and as the percentage of nitrogen is an indication of nutritive value the following examples are quoted of percentages of nitrogen in dried fungi:—

Cantharellus	Boletus	Russula	Lactarius	Agaricus	Morel	Truffle
3·22	4·7	4·27	4·68	7·26	8·23	15·35

In comparison with other vegetable foods the percentages of proteids are:—

Truffle	Morel	Mushroom	Lentil	Peas	Wheat	Rye	Potatoes	Turnips, etc.
35	36·25	26·31	29·33	28·02	16	12	1·5	1·5

Even the poisonous fungi contain much nutritious food material and would be equally valuable if their poisonous elements could be eliminated, some of which are volatile and can be dispersed by high cooking, others are rendered innocuous by the application of vinegar and salt.

A short list of esculent Fungi, nearly all of which have been tested at the Forays of the Mycological Section.

#### SPRING SPECIES.

*Marasmius oreades*  
*Tricholoma gambosum*  
*Morchella esculenta*

Fairy ring champignon.  
St. George's Mushroom.  
Morel.

## AUTUMN SPECIES.

<i>Amanita rubescens</i>	Blusher.
<i>Amanitopsis vaginatus</i>	Grisette.
<i>Armillaria mucida</i>	Beech tuft.
<i>Lepiota procera</i>	Parasol.
<i>Tricholoma personatum</i>	Blue-stalk.
<i>T. nudum</i>	Wood blewit.
<i>T. grammopodium</i>	Striped Stalk.
<i>Pleurotus ostreatus</i>	Oyster of the Woods.
<i>Agaricus campestris</i>	Pasture Mushroom.
<i>A. arvensis</i>	Meadow Mushroom.
<i>Coprinus comatus</i>	Shaggy Inkcap.
<i>C. atramentarius</i>	Smooth Inkcap.
<i>Hygrophorus pratensis</i>	Field Apricot.
<i>H. niveus</i>	Snowdrop.
<i>Lactarius deliciosus</i>	Delicious Red-Milk.
<i>Cantharellus cibarius</i>	Chanterelle.
<i>Boletus edulis</i>	Dainty bolet.
<i>B. scaber</i>	Rough bolet
<i>Fistulina hepatica</i>	Beefsteak.
<i>Hydnum repandum</i>	Wood urchin.
<i>Clavaria vermicularis</i>	White Coral Tufts.
<i>Lycoperdon Bovista</i>	Giant Puff Ball.
<i>Helvella crispa</i>	Brittle Helvel.
<i>Peziza badia</i>	Brown Elf Cup.
<i>P. vesiculosa</i>	Bladder Elf Cup.

The question at once arises : How can this vast supply of food be made available for public use ?

There are many ways of doing this which quickly suggest themselves to our minds.

Instruction in schools should be given of some elementary knowledge of Fungi ; models and coloured illustrations, like the large wall maps prepared by Worthington Smith and others, might with great advantage be exhibited in schools, and the scholars invited to collect and compare specimens with the models and illustrations, and by periodical exhibitions of named specimens. In the Nature Study Classes, which are formed mainly of the teaching community, there is a great amount of ignorance with regard to the nature of Fungi, especially their edible and poisonous properties and their economic importance generally, some progress is being made, but much more remains to be done to remove this ignorance and prejudice.

It must be borne in mind that there is no golden rule to distinguish the good from the bad, such as the peeling of the cuticle, or testing with silver spoon or golden ring or such like fancies, but the characters of a dozen good eatable species are as soon acquired as those of a dozen flowering plants.

In many of the continental countries Fungi are more used for food than with us in England. They are not only used in the fresh state but are preserved or dried for winter use. Here the only one generally used is the common Mushroom,

but in France and Italy other species are more esteemed, as a visit to the markets testifies. In many places an inspector of Fungi examines and gives certificates for the sale of Fungi brought to the market and condemns that of a doubtful nature.

Ergot of Rye *Claviceps purpurea* (of which I shall later on have to mention as a pest), holds a place in the *Materia Medica* on account of its active principles and is employed as a vaso-constrictor in uterine hæmorrhage.

The Giant Puffball, *Lycoperdon Bovista*, is still used in our country places as a styptic. Even a century ago, important surgical operations were performed under its influence as an anodyne and styptic.

The mycelium of *Chlorosplenium aeruginosum* stains wood a rich blue-green colour and the wood thus coloured was much used formerly for many ornamental purposes.

Cheese ripening is due to fermentation caused by bacteria, and the blue mottled colouring and flavour to the mould *Penicillium glaucum* which develops readily in the spaces of unpressed cheese like Stilton, Wensleydale and Gorgonzola, whilst in pressed cheeses of a more homogeneous nature like Cheddar and Cheshire, the spores of the fungus are unable to mature owing to lack of air and oxygen which the interstices of the former cheeses provide.

Brewing and Wine and Cyder making are dependent on Yeast, *Saccharomyces cerevisiæ*, for the conversion of the sugar in the wort into alcohol, emitting during the process  $\text{CO}_2$  (carbonic acid gas).

It is found that the terminal rootlets of some plants are are invested with fungus hyphæ forming root caps which do not appear to be detrimental to the host but are in some cases actually necessary to the existence of the plant. This partnership or cohabitation has been termed symbiosis, and the organs performing the symbiosis of root and fungus have been named mycorrhiza or fungus-roots which seem to perform the functions of root hairs.

Symbiosis is known to occur in several Orders and Genera of plants, viz., Cupuliferæ, Salicacæ, Abietinæ, etc., certain of the Orchideæ and some of the Ferns and Lycopods. These fungus-roots are found where much humus exists in the soil and are absent from the roots of plants growing in poor soil with small humus content. The fungus is able to utilise the organic material of the humus and convey it directly in some form to the plant. Although the case is still *sub judice*, it is possible that these fungus-nurses contribute more to the sustenance of the higher plants, including the cereals and forest trees, than has hitherto been supposed.

It is known to farmers that the Leguminosæ (Peas, Beans, Vetches, Clover, etc.) in conjunction with certain species of

soil bacteria, have the power of fixing the atmospheric nitrogen and storing it up in their roots in the form of nodules, which act beneficially on the following crops. This action of the nitrifying bacteria is produced under the influence of the fungus *Rhizobium leguminosarum*.

The Leguminous plants develop these root tubercles most readily in soil deficient in nitrogenous food substance and less in soil rich in humus and nitrogenous matter.

Virgil (b. B.C. 70), when writing on the cultivation of the soil in his *Georgics*, Book I., is aware of the advantage of a corn crop following a leguminous one when he says :

' . . . where, vetches, pulse, and tares have stood,  
And stalks of lupines grew (a stubborn wood),  
The ensuing season, in return, will bear  
The bearded product of the golden year : '

Dryden's Translation.

Having said so much for the good influences of Fungi, we may now consider how they militate to the injury of mankind, by lessening the food supply or by damaging its quality by means of the many forms of plant diseases which go by the names of smut, rust, mildew and blight in corn, canker and rot in fruit, 'demic' disease in potatoes, and many others so well-known to farmers, gardeners and timber growers.

The number of diseases to which human flesh is heir, is exceeded by the number of diseases to which plants are liable ; and as the study of human diseases has resulted in the alleviating and in the prevention of much suffering and loss of life ; so the study of the life history of these fungal diseases furnishes us with the means of combating them, and thereby lessening the loss on our corn and fruit crops and our timber supplies.

Such knowledge empowers us with the means to receive the most good from the hands of Nature and to avoid that which might be injurious.

It is not easy to estimate the world's annual loss from the depredations of Fungi, but competent authorities are agreed that the total loss caused by fungi to corn, fruit and timber exceeds £300,000,000 per annum, much of which could be averted by remedial measures.

In this direction reference may be made to the statistics issued by the Agricultural Department of the United States where plant diseases are more studied than in any other part of the world.

The principal estimated losses recorded are as follows :—

The annual loss from	Rust in Wheat	... ..	£15,000,000
"	"	Potato Disease	... .. £7,000,000
"	"	Vine Disease in California	£2,000,000
"	"	Smut in Wheat	... .. £3,000,000
"	"	Bitter-rot in Apples	... .. £2,000,000

Naturalist,

totaling, with some of the minor diseases, to over £50,000,000 per annum. The Prussian statistics for the year 1891 estimate the injuries to corn crops alone, to be over £20,000,000.

No statistics are available for Britain, France, Russia, Canada, Australia or South America.

These figures will suffice to emphasize the destructive effect of plant diseases when not under control.

One of the most destructive of the parasitic fungi is the Rust of wheat (*Puccinia graminis*) which affects the leaves so much as to lessen the vitality of the plant, thereby reducing considerably the quality and quantity of the corn produced.

This fungus pest has been known for thousands of years ; many of the ancient writers refer to it, Pliny several times mentions it, and in one passage calls it 'the greatest pest of the crops.' They tried to account for its presence in various ways such as evil spirits,\* the weather, lightning, blight, wrath of the Almighty, etc. Virgil suspected the proximity of Juniper bushes to be the cause when he says :

'From Juniper unwholesome dew distil,  
That blast the sooty corn, the withering herbage kill.'

Pastoral X.

The Romans held on April 25th in each year a festival called Rubigalia to implore their deities to ward off the Rust disease and to protect their crops from this fungus pest.

The study of the life history of this Rust disease has been for many years pursued by plant pathologists on account of its importance economically, and of its great interest biologically as it passes through three well-defined stages in its existence, each of which was formerly considered a separate entity.

The first appears in spring on the leaves of Barberry and shrubs of that natural order in the form of yellow cluster cups producing spores (*æcidiospores*) which, when carried by wind and other agencies, infect the young wheat plants, causing them in a few weeks to have a rusty appearance due to small bright orange patches filled with power (*uredospores*) and the infection of the surrounding plants quickly takes place. From these same patches, a few weeks later, another set of spores arise, purple black in colour (*teleutospores*) which lie dormant all the winter and infect the Barberry leaves in spring.

For two or three centuries past it was noticed that the presence of the Barberry had an injurious effect upon the wheat crops, and a law was passed in 1755 for the extirpation of all Barberry bushes in the province of Massachusetts in America,

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\* . . . The foul fiend Flibbertigibbet mildews the white wheat.

King Lear, Act III., Scene IV.

but the biological connection between the three forms of the pest was not suspected until Professor De Bary in 1864 proved by cultures that they were three stages in the life history of the fungus plant *Puccinia graminis*.

The wild barberry is absent from this district but the Rust disease is very prevalent, and there is still some uncertainty how the pest gets over the winter months under these circumstances. Experts are of opinion that the uredo or summer spores perpetuate the disease by infecting grasses in sheltered places and perhaps by the mycelium of the uredospore lying dormant in the grain.

Nearly two hundred species of Rusts have this heteroecious mode of life.

The Bunt in Wheat (*Tilletia Tritici*) is another pest which unlike the Rust completes its life-cycle on the same plant, infecting it at an early period and growing up through the season in the tissues of its host, appearing at harvest as black spore masses within the chaff. When this sooty mass is bruised, it emits a disagreeable fishy odour which is often perceptible in the holds of wheat-laden ships, indicating its presence in the wheat-growing countries abroad.

The infection takes place whilst the plant is in the seedling stage and it is noticed that where a plant is infected, it is always found that every ear of the plant and every grain in each ear is destroyed. This would not always be the case if the plant was infected at maturity by spores conveyed by the wind or other agencies.

The disease is more prevalent in spring-sown than in autumn sown corn, the reason being that the late autumn weather is not so favourable to spore germination as the spring, and in the case of autumn-sown wheat the young plant by springtime is proof against infections.

Gerard the botanist, writing in 1597, on the pests of the Corn Crops, says:—

I. *Hordeum ustum* or *Ustilago Hordei*, is that burnt or blasted Barly which is altogether unprofitable and good for nothing, an enemy unto corne; for that instead of an eare with corne there is nothing els but blacke dust, which spoileth bread or whatsoever is made thereof.

II. Burnt Otes or *Ustilago Avenae* or *Avenacea* is likewise an unprofitable plant, degenerating from Otes, as the other from barly, rie and wheat. It were in vain to make a long harvest of such evil corne, considering it is not possessed with one good qualitie. And therefor thus much shall suffice for the description.

III. Burnt Rie hath no one good property in physicke appropriate either to Man, Birds, or Beast and is an hurtful maladie unto all Corne where it groweth, having an ear in

shape like to Corne, but in stead of graine it doth yeeld a blacke powder or dust, which causeth bread to looke blacke, and to have an evill tast: and that Corne where it is, is called smootie Corne and the thing it self, Burnt Corne, or Blasted Corne.

Three woodcuts are given, perhaps the oldest pictures known of the effects of the pest *Ustilago*. These woodcuts, illustrating Gerard's Herbal, were printed from blocks procured from Frankfort, being the same blocks which had been used for the 'Kreuterbuch,' the German Herbal of Tabernæmontanus in 1588.

Ergot of Rye (*Claviceps purpurea*) produces terrible effects when taken into the alimentary canal by man or animals, causing gangrene of the extremities and other maladies. It has the effect of causing muscular contraction and by stopping the supply of fresh blood to the limbs causes them to rot and fall off. It is also extremely injurious to sheep and cattle during the breeding season. Ergot may be observed in almost every rye field during June and July by the blackish horn-like growths taking the place of the grain and projecting from the ears often an inch or more in length. Many of these sclerotia (=compacted mycelium) fall to the ground and remain dormant until the spring, when they produce small drumstick-like bodies covered with flask-shaped cavities filled with spores which, when liberated, infect the flowers of the corn. Many of the grasses and sedges are affected with ergot in a similar manner to the corn crops and are able to convey the infection to the cereals, although it is noticed that the ergots on grasses vary their time of germination to suit the flowering period of their hosts.

That the ergot of grasses infect corn was suggested last summer by the appearance of a rye field on the edge of a common in the Selby district which was affected to quite ten per cent. whilst near by the wild grasses *Lolium perenne* and *Holcus lanatus* were similarly affected, but in the part of the field distant from the grasses the infection of the crop did not reach one per cent. In this country, where the practice of crop rotation is generally followed, the diseases of the crops are not so virulent as where constant growth of the same crop prevails, the interval being usually sufficient for the decay of the resting spores although the vitality of some species is remarkable, for instance, Ergot. In the spring of 1916, some sclerotia of this, labelled July, 1880, was taken from the cabinet and placed on moist sand in a Petrie dish, and in about a month several ascophores of *Claviceps purpurea* were developed so that the thirty-six years of complete dessication had not destroyed the vitality of the plant.

Crop rotation has been able to ward off the Black Wart disease of Potatoes (*Synchytrium solani*), a pest which has

lingered for several years in some allotment gardens near Selby, where year by year the potato is the staple crop but is quite unknown to the farmers in the district where the usual crop rotation is observed, although experiments at Kew prove that the resting-spores in the soil are capable of imparting the disease for five years. The spores are  $40 \times 70\mu$  diam. and are not so easily carried by the wind as are those of *Phytophthora infestans*, which measure only  $25 \times 15\mu$ .

The Potato Disease (*Phytophthora infestans*), which causes such enormous losses in favourable seasons, made its appearance in this country in 1845, and is now known in every part of the globe where the potato is grown.

In dry weather, it does not assert itself, but when favoured by moist warm weather the disease becomes of serious importance. The usual mode of infection is through the leaves by conidia brought by the wind. Each conidium contains six or eight oospores which when liberated germinate at once on the moist leaves and send out tubes penetrating the stomata or boring through the cuticle, down the stems to the tubers, which may either be destroyed at once or they may receive the infection so lightly as to remain apparently sound until the following spring; these, when planted, produce the disease in their offspring, ready to break out under favourable climatic conditions to complete the life-cycle.

The American plant-pathologists have much confidence in the spraying of the plants with Bordeaux mixture; (Copper sulphate 5 lbs., Quicklime 5lbs., Water 50 gallons). They claim that by spraying the disease is held in check, and also that the fungicide invigorates the foliage.

The principle fruit disease with us is the Apple Scab and Canker (*Venturia inæqualis*). The variety of fruit bearing the disease is usually condemned instead of laying the blame on the pest, and very little attention is paid to its eradication, but in the South and West of England, Canada, the United States and Australia, where pomaceous fruits are extensively grown, every endeavour is made to cope with it by pruning and spraying, which methods are in the main successful.

Our timber trees bear parasites which, unlike the microscopic ones previously mentioned, are composed chiefly of large agarics and polypores. The destruction of the wood is caused by the mycelium permeating the tissues of the wood like the dryrot fungus (*Merulius lacrymans*), or by sending out cord-like strands between the wood and the bark, robbing the host of its sustaining fluids and eventually causing strangulation.

The questions will naturally be raised: 'Has the biological study of these organisms resulted in any economic success?' The answer is Yes, decidedly. For instance:—

THE PINE DISEASE (*Peridermium pini*) may be exterminated by clearing away all plants of the Genus *Senecio* (Groundsels and Ragworts) upon which it passes one of its life-stages.

ANBURY OR FINGER AND TOE. (*Plasmodiophora brassicæ*) in Cruciferous plants (Turnips, Cabbage, etc.), can be prevented by making the soil non-acid by limeing and by keeping in check weeds of the same Natural Order in the field sides and headlands.

FRUIT SCAB AND CANKER (*Venturia inæqualis*) is averted by spraying with Bordeaux mixture and by pruning off the infected twigs.

THE DAMPING OFF OF SEEDLINGS (*Pythium debaryanum*) is checked by ventilation and similar treatment as for Anbury.

SMUT AND BUNT IN CORN. (*Ustilago* sp. and *Tilletia tritici*) may be minimised by dressing the seed corn with formaline or copper sulphate.

DRYROT IN TIMBER (*Merulius lacrymans*) may be prevented or eradicated by proper ventilation and by the application of creosote solution.

We read much about the breeding of plants which are immune to certain diseases, but we have yet to learn of what this so-called immunity consists. Is it because the stomata are too small for the germinating hyphæ of the spore to enter, or is the virtue in the harder and less succulent epidermis of the plants? Dr. A. D. Selby has pointed out that in the study of disease susceptibility it has been shown that other features being the same, the percentage of water is an index: thus, parts having the higher water content are attacked more readily than those with a lower water content.\*

Few will doubt that certain plants have been raised which, so far, are disease resistant, and we must be thankful for these, even if their raising has been brought about by guesswork methods; there is, however, the fear that when circumstances of climate, soil or moisture are favourable, the disease will reassert itself. In this district the Potato is extensively cultivated and any fact relating to its growth or life history is of interest.

Some years ago I pointed out to Mr. Massee that the microscopic structure of tubers immune to and those subject to the disease (*Phytophthora infestans*) differed, inasmuch as the former has much thicker cell walls than those of the latter. Mr. Massee desired me to verify this by growing a number of varieties under the same conditions of soil, climate and moisture, and he sent me some thirty or forty named sets, which were planted and grown in a plot under the same conditions, when further microscopical examination was made confirming my

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\* Ohio Exp. Sta. Bull., 214. March 1910.

previous results; thus the varieties with thick cellulose cell walls were always watery or soapy when cooked and the varieties with thin cell walls were always mealy or floury.

When a variety is newly raised from seed it has a thick cell wall and is consequently undesirable in the market for its cooking qualities, however desirable it may be for its productiveness on yielding larger and better shaped tubers. It is then to a great extent resistant to the disease; after a period of growth, the cell walls become thinner and the tuber more desirable for the table, but often losing its high productivity, and at the same time becoming more susceptible to disease; hence many of the old varieties are completely discarded on that account, although much esteemed for table purposes.

It was recently pointed out in the *Journal of Agriculture* that the enzyme, the function of which is to convert the starch into sugar so as to be directly available for growth, has to a great extent ceased to exist, hence growth or sprouting is checked, and it is now believed that this enzyme existing in considerable quantity in a thick cell-walled tuber is the natural fungicide protecting the plant against the attacks of its pest.

Eight to twelve years seems to be the period a variety of potato takes to run from infancy to old age, when its vitality is lowered, is then subject to disease, and its productivity much diminished. A fillip may be given to the plant by a change of soil and climate, even as sometimes a change of air and occupation is to ourselves.

Many troublesome skin diseases such as Ringworm, Barbers' rash, Thrush in infants, etc., are attributable to fungi, in fact all human diseases which are infectious or contagious are caused by micro-organisms which may be regarded as of a fungoid nature. The salmon of our rivers and the gold fish of our ponds often suffer from a destructive parasite (*Saprolegnia ferax*) which causes the fish to become sick, sluggish and eventually to die, but broadly speaking, Fungi seem to be more fatal to insects than to the other branches of the animal kingdom. Much loss is caused in some years by the malignant silkworm-disease (*Botrytis Bassiana*) and beekeeping is becoming almost impossible at home in consequence of the scourge known as the Isle of Wight bee disease, which has so far baffled experts to counteract. Some insects seem to have a tendency to favour the attacks of a singular class of parasitic fungi, the mycelium of which permeates the dormant and buried chrysalis, sending out an orange-red fleshy club-shaped stem projecting two or three inches out of the ground and tuberculose with flask-shaped bodies containing spores in asci. This fungus (*Cordyceps militaris*) is not uncommon in damp woods during the autumn months. It is a debatable point whether the fungus is parasitic or saprophytic, but the stronger weight

of evidence is towards the former character. A rare species of this group with a globose head (*C. capitata*) was found at one of our forays two years ago.

Some wonderful examples of Cordyceps often reaching to six or eight inches in length are found in Australia and New Zealand; they are eaten by the Maoris as a *bonne bouche* and are also collected and sold to visitors as curiosities.

I trust the few examples I have given of beneficial and injurious Fungi will suffice to show the important part Fungi play in the economy of Nature, and that the study of Mycology is worthy of our serious consideration.

National legislation might be profitably directed to the employment of universal measures for combating fungoid plant-diseases, the individual efforts, however well applied, will be nullified by careless neighbours as the spores are in most cases windborne. Laws are provided for protecting man and animals from infectious diseases and it is also essential that the infection of our crops should be guarded against by:—

- (I.) Instruction by experts in the nature of plant diseases, their appearances and easy recognition, methods of prevention and remedies for the control, checking, or extirpation of the destructive parasitic organisms.
- (II.) The exhibition of affected plants in museums and educational centres.
- (III.) More stringent means for preventing the introduction of fresh diseases into new localities or countries.
- (IV.) To inculcate the value of crop rotation, whereby the continuity of the life-cycle of the fungus is broken.
- (V.) Further study and investigation into the nature of resistant and non-resistant crops.
- (VI.) The removal of complementary hosts in infected areas.
- (VII.) Further experiments in the efficacy of spraying, protective to the host and destructive to the parasite.
- (VIII.) The appointment of more mycologists, specially trained in plant-pathology.

Let me recommend to the delegates of Yorkshire Naturalists' Societies the encouragement of the study of Fungi by their botanical members. Some previous botanical knowledge is really necessary, before entering the field of Mycology, but one is convinced they would find this an attractive and interesting section, furnishing work at a time when most of the flowering plants are at rest. To the microscopist, Fungi present objects of great beauty and diversified forms.

Full use should be made of the British Museum booklets on Fungi and Mycetozoa, which are alone sufficient to enable students to recognise very many species commonly found in all districts. The drawing, painting and photographing of

specimens is advised, as work of this kind enables the student to grip the characters and leading features better than by any other means, for after a drawing or painting is made the image of the plant and its salient features are often strongly impressed upon the memory.

A leading spirit is very desirable to give inspiration and guidance, and this must be found, if not amongst the members themselves, then such a leader must be sought for in some expert outside the Society.

The specimens and classification should be explained and described in simple language so as not to deter the student.

Scientific terminology is quite right when the majority of the audience can follow the speaker, but it is often discouraging to the earnest enquirers for information; it must be remembered that most of our members in local Societies have not had the previous training to enable them to understand the mysteries of Nature couched in professional phraseology. Let them be led by degrees to unfold the treasures which Nature offers to those who seek her shrine.

After the student has decided to take up the study of Mycology, a general review should be made of the classification, and before long, some section of this large subject will appeal to him. It is very desirable that whilst knowing 'something about everything,' he should endeavour to know 'everything about something;' in other words he should specialise on some particular class, order or genus. By so doing, he will derive more pleasure and satisfaction, and also be able probably to contribute a mite to the general stock of knowledge on his particular selected subject.

The student must not be content with names alone, but should strive for an intimate knowledge of the structures, forms and life histories of these organisms which are often of great microscopic interest, opening out thereby a new world of beauty and wonder with appearances as diversified and fruits as multifarious as the trees and plants of the familiar world, to be enjoyed only by those who delight in perusing the picture book of nature.

And Nature, the old nurse, took  
The child upon her knee  
Saying 'Here is a story-book  
Thy Father has written for thee:'  
'Come wander with me,' she said,  
'Into regions yet untrod,  
And read what is still unread  
In the manuscript of God.'

LONGFELLOW.



